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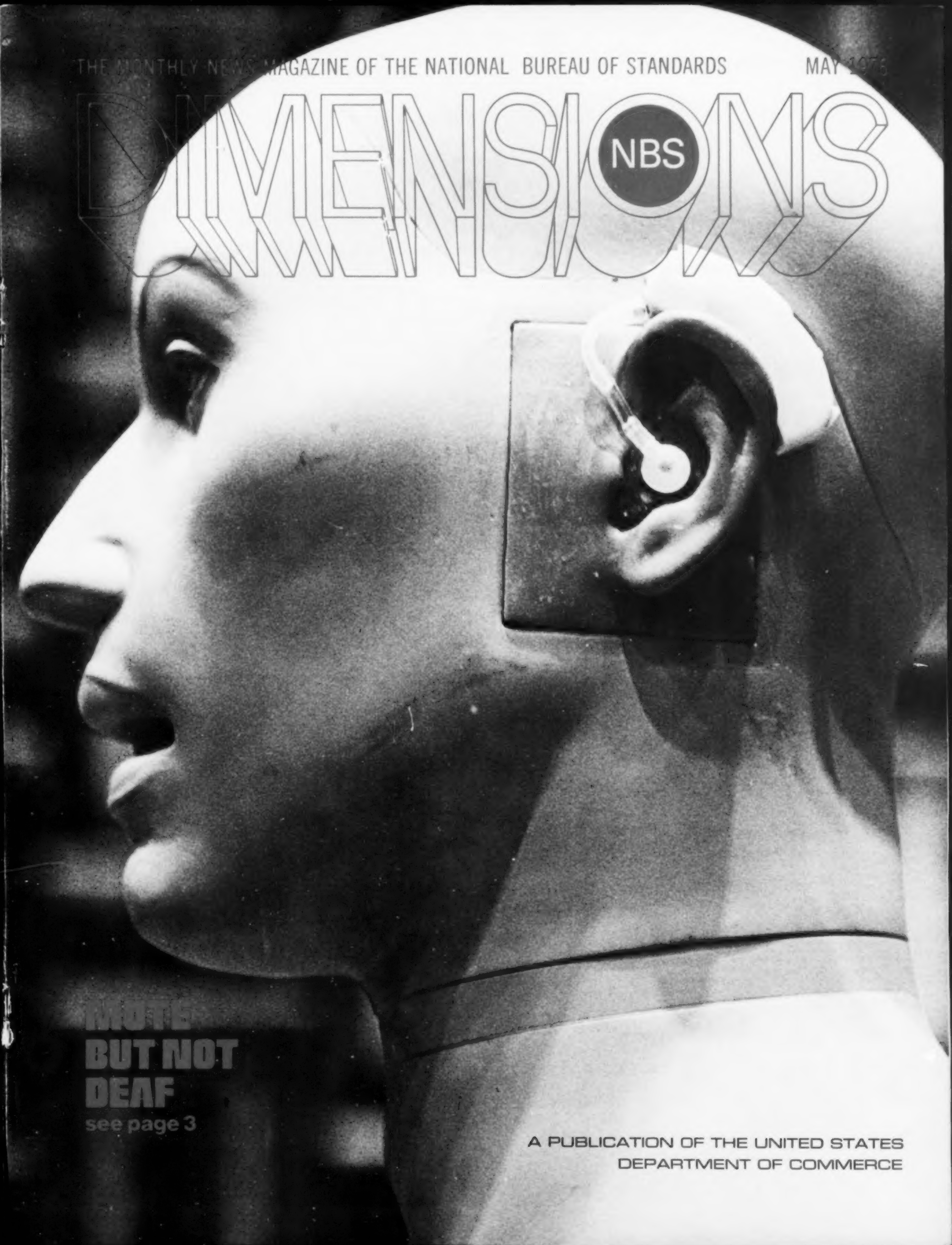
# DIMENSIONS NBS



MUTE BUT NOT DEAF

see page 3

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NATIONAL BUREAU OF STANDARDS

# DIMENSIONS NBS

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*Cover:* An anthropometric manikin used by the National Bureau of Standards for acoustic research "listens" through an over-the-ear hearing aid in an anechoic chamber as part of a testing program conducted for the Veterans Administration. Story on page 3.

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:
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# LISTEN CLOSELY

## Testing Hearing Aids for Veterans

by Michael Baum
staff writer

STANDING mute, but not deaf, in the center of a test chamber at the National Bureau of Standards, is a special manikin. Called an anthropometric manikin, it is built to the shape of the average human torso and head, and although it can't speak, it can hear because it is the latest addition to an NBS program that tests hearing aids for the Veterans Administration.

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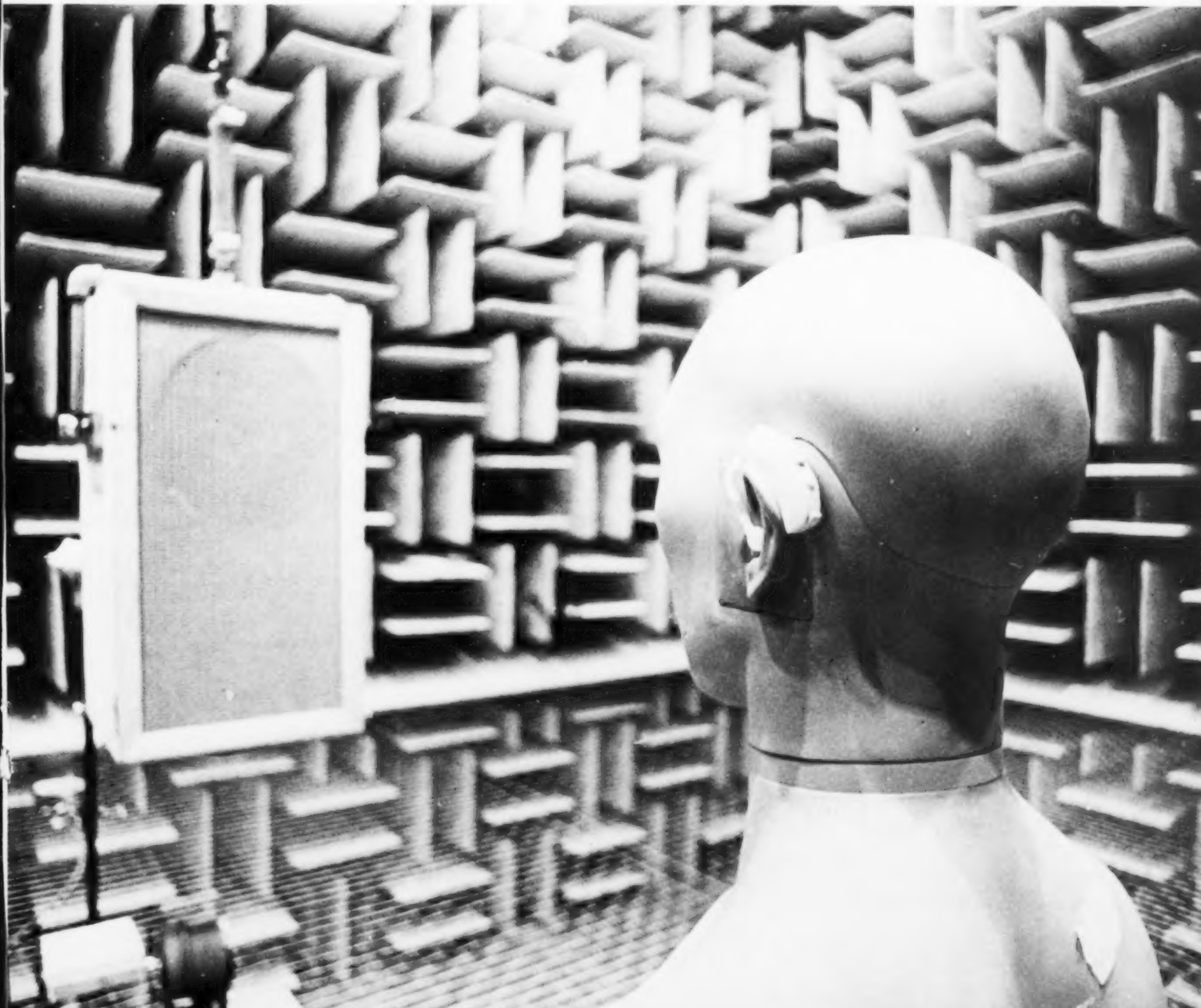
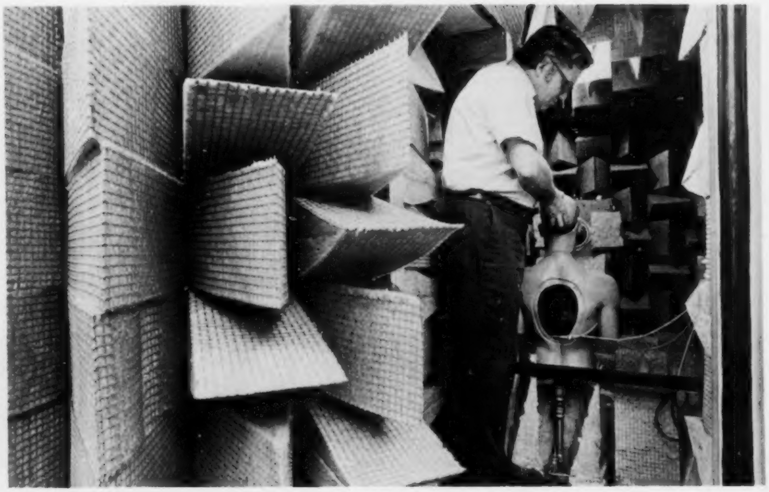


Physicist Edwin Burnett, framed by the sound-absorbing wedges of an anechoic chamber, finishes adjustments to the Zwislocki couplers inside the manikin's head that simulate human ear canals and ear drums.



**HEARING AIDS** *continued*

Hearing loss, which can be brought on by over-exposure to loud noise, is an occupational hazard in the armed services, although modern safety procedures are making it less common. Last year the Veterans Administration reported issuing over 14,400 hearing aids to veterans with hearing disabilities, and other departments and agencies that buy hearing aids through the VA, including the armed services, issued another 4,100. The cost of these hearing aids was over $1.9 million.

There are more than 500 hearing aid models available in the United States, of all different designs and degrees of quality. To help the VA decide which hearing aids to buy, the Sound Section of the NBS Institute for Basic Standards, together with the Biocommunications Laboratory of the University of Maryland, tests over 100 different models of hearing aids each year.

"We supply the numbers to the Veterans Administration," explains NBS physicist Edwin Burnett, "and they do the ratings."

The numbers supplied by Burnett, who has been the project's leader since 1960, and technician Martin Bassin, represent the electrical and acoustical properties of the hearing aids. Last year numbers were supplied for 360 hearing aids—120 different models, 3 samples of each model.

## Anechoic Chambers

Testing a hearing aid requires special conditions, one of which is silence. Most of the NBS tests are performed in a small anechoic—or echoless—chamber. Wedges of fiberglass line the sides of the chamber, filling all but 1.8 cubic meters of space. The wedges absorb more than 99 percent of the energy of any sound with a frequency above about 175 Hertz (on a piano, about F below middle C).

In this echoless environment, "ordinary" hearing aids are tested. These include the familiar "behind-the-ear" models, which are built into small curved cases that are worn looped around the ear; the small, and less powerful in-the-ear hearing aids; the powerful but somewhat cumbersome on-the-body aids, and hearing aids built into eyeglass frames.

Most of these hearing aids are used with a "closed" ear mold, a plastic plug custom tailored to the user's ear, that channels the sound from the hearing aid into the ear while simultaneously blocking out other signals. Testing a hearing aid with a closed ear mold and an omnidirectional microphone (equally sensitive to sound in all directions) is comparatively simple. The hearing aid is placed in the anechoic chamber, together with a loudspeaker to provide a sound source, and a reference microphone which measures and controls the sound applied to the hearing aid. The hearing aid itself is attached to a coupler, a small cavity that simulates the human ear canal with a microphone in place of the ear drum. Cables connect the microphones to recording and analysing instruments outside the chamber.

Results from these tests can be misleading however, simply because they do not simulate the effect of wearing the hearing aid on a human body. Certain types of "special purpose" hearing aids especially need to be tested in an environment that physically simulates the conditions in which they are actually used. These special purpose hearing aids include those with directional microphones—designed to emphasize sound coming towards the front of the head—hearing aids without closed ear molds, and the so-called bi-CROS hearing aids, which have microphones on both sides of the head.

## "Special Purpose" Aids

NBS researchers are now developing techniques to measure the performance of these special purpose hearing aids. KEMAR, the Knowles Electronic Manikin for Acoustic Research, is being used for these tech-

*In a test for harmonic distortion, Burnett adjusts the frequency of the input signal to the hearing aid. The screen at right displays the relative amplitudes of the input frequency (tall line segment) and harmonic frequencies produced by the hearing aid (short segments).*

niques. Constructed of fiberglass reinforced polyester, with a lead filler, the dummy is the size and shape of an average human torso and head. A behind-the-ear hearing aid with a directional microphone can be placed on its ear to study how the shape of the ear and head affect the directionality of the hearing aid.

Some hearing aids are fitted with so-called "open mold" ear pieces, which are basically just skeletons to hold the tube that brings sound from the hearing aid to the ear. Unlike closed molds, they do not fill the ear and block the direct sound. Such hearing aids cannot be tested in the usual way—their performance depends on the shape of the ear canal. The manikin's head "listens" through a microphone which is in a device called a "Zwislocki coupler" that approximates the behavior of a human ear canal and ear drum.

Another use is to measure orthotelephonic frequency response (OFR), the difference in sound level at the eardrum with and without the hearing aid. Because one of the factors on which OFR depends is how the sound

*turn page*

*This over-the-ear hearing aid has a directional microphone designed to selectively emphasize sound coming towards the front of the head. To test it under conditions similar to actual use on a human head, it is placed over the manikin's ear.*

waves bend (diffract) around the head, the manikin is used to determine the OFR of open mold hearing aids.

KEMAR will be used for the first time in hearing aid tests performed for the 1977 contract year, which will emphasize the special purpose hearing aids. Burnett and engineer George Kuhn spent 3 months "calibrating" the manikin, a process that involved measuring the sound field around its head with a microphone probe to determine how the sound pressure level varied with different positions and different frequencies.

### Understanding Test Results

The special tests that will involve the KEMAR manikin are still in the developmental stage, according to Burnett, and will probably undergo changes. The test program for regular hearing aids—those with omnidirectional microphones and closed ear molds—while well established will probably also change in order to reflect the improved significance of the results obtained from the tests on the manikin.

The most important test, according to Burnett, regardless of the technique used, is the determination of the frequency response—how the amplification of the hearing aid changes with different frequencies. "Gain is the amount by which a signal that goes through a hearing aid is raised—anywhere from 30 dB (decibels) to 70 dB," explains Burnett. A 30 dB boost raises a soft whisper to about the level of conversational speech. A 70 dB gain raises the whisper to about the same sound level a bystander hears when a trailer truck passes him on the road. Adds Burnett, "Hearing aids have more gain at high frequencies than low frequencies, usually, because people generally have more hearing loss at high frequencies." Another consideration, he says, is that a high gain at the higher frequencies makes speech more intelligible.

A frequency response curve, plotting gain versus frequency, is made for frequencies between 200 and 5,500 Hertz (roughly between G below middle C and an F 4½ octaves above C). As a general rule, according to Burnett, the VA desires hearing aids whose gain increases 5 dB for every octave increase in frequency, but many hearing aids are designed with other types of frequency responses in order to compensate for various kinds of hearing loss.

In addition to the gain and frequency response, the saturation sound pressure level, signal-to-noise ratio, and harmonic distortion are also found for each instrument.

Saturation sound pressure level (SSPL), according to Burnett, is the highest sound level that the hearing aid will produce. It is found by subjecting the hearing aid to a noise having well-defined parameters and monitoring its output sound level. The noise volume is gradually increased until the hearing aid's output sound level stops increasing. That level is the SSPL, a single number that gives an approximation of the maximum amount of sound that could impinge on the user's ear. To meet VA requirements, the SSPL must be not less than 97 dB, a level about equivalent to standing next to a typical power mower.

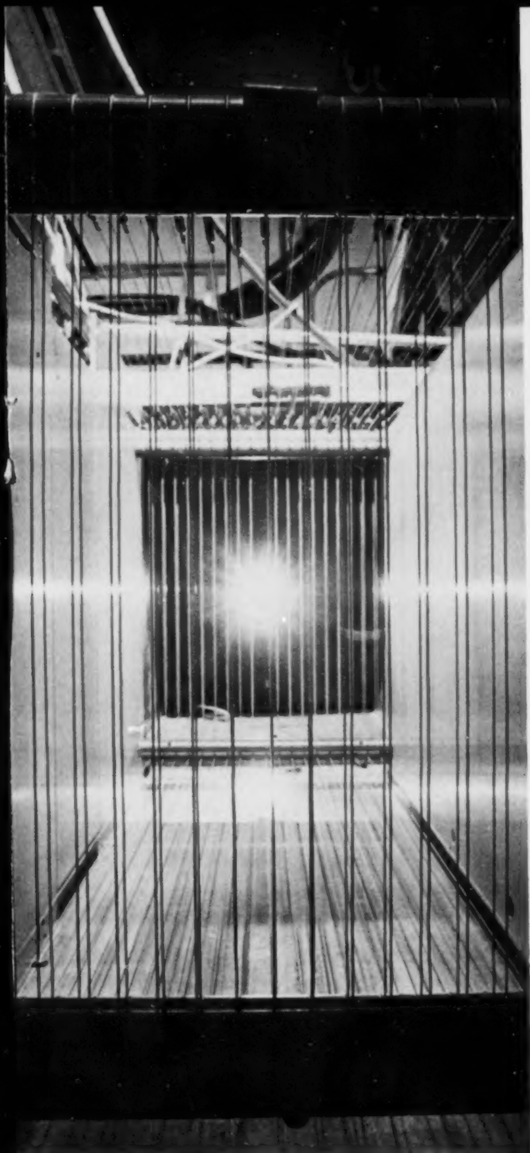
The signal-to-noise (S/N) ratio is a measure of noise produced by the hearing aid itself. It is calculated from the difference between the hearing aid's output level when receiving a certain tone at a certain volume, and the output level when no sound is being received.

Harmonic distortion, like the S/N ratio, is a product of the hearing aid's circuitry. Harmonic distortion occurs when a tone of one frequency going into the aid produces that frequency plus one or more of its "harmonics" —frequencies that differ from the original by some integer multiple. There are many unknown factors remaining about the exact effects of harmonic and related distortion. "But we do know" says Burnett, "that such distortion makes speech sound fuzzy. It's really destructive of music, and it's even worse yet if you have a lot of background noise in with the signal."

In addition, the "battery drain"—the amount of battery current the hearing aid draws—is measured. Most modern hearing aids are powered by small cells similar to the ones used in electric watches. The cost of replacing hearing aid batteries, which, Burnett says, last anywhere from a few days to a week or more, can be quite high over a period of tme.

The results of the NBS testing program are published each year by the Veterans Administration and are available to interested dealers and consumers. The most recent issue, Handbook of Hearing Aid Measurement, 1976, Stock No. 051-000-00090-1, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, $5.45.

Another useful publication is *Facts about Hearing and Hearing Aids,* an NBS Consumer Information Guide, Stock No. 0303-0920, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, $1.10. □



(Photo by Mark Helfer.)

*Light beams shine down a path normally taken by x-rays in this free air ionization chamber (opened up for the photograph). The guard wires circling the chamber help produce a uniform electrical field between the high voltage and collector plates of the measurement device, a design developed by Lauriston Taylor in 1929.*

# A SAGA OF RADIATION SAFETY

**by Lauriston S. Taylor**

Lauriston S. Taylor was formerly Chief of the Atomic and Radiation Physics Division at the National Bureau of Standards and later an Associate Director of NBS. He served the National Academy of Sciences as a Special Assistant to the President for emergency planning on recovery from nuclear attacks and is now President of the National Council on Radiation Protection and Measurement. The following article is excerpted from his March 1 keynote address to the Measurements for the Safe Use of Radiation symposium sponsored by the NBS Institute for Basic Standards.

THE required accuracy of measurement of radiation depends to a considerable extent upon the purpose to which the measurements will be applied. Our technology places limitations upon accuracy, but it is usually found that by the time greater accuracy is required, our technology is on hand to accomplish it. Usually improvements in technology create the new needs, and so in most instances they go hand in hand.

It is all very well to be able to measure a quantity with high accuracy in, let us say, a central standards laboratory such as the National Bureau of Standards. However, it would serve no purpose if the NBS standards could not be intercompared with the standards in other laboratories and could not be applied through secondary instruments to applications in the field. Since there may be a number of steps between the measurement in a standards laboratory and a measurement in, let us say, a hospital, it is important that there be a high level of assurance that the end measurements carry the required accuracy. We thus have a direct necessity for what would be called "trace-

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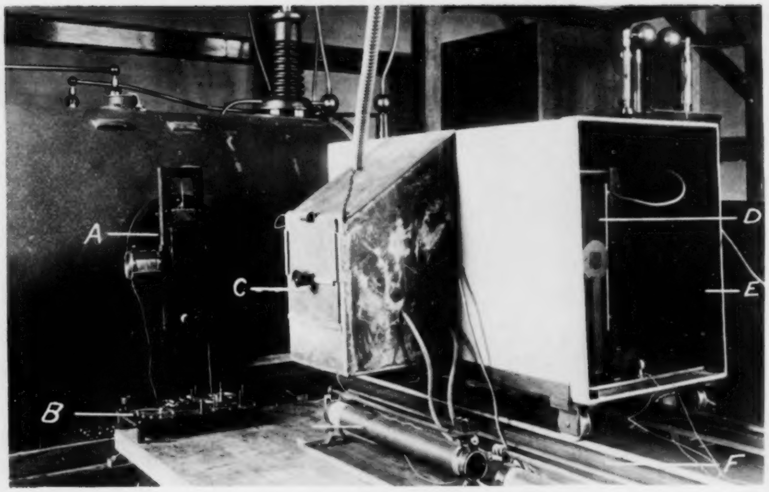
ability" or "measurement assurance." Measurement assurance can be critical for a variety of reasons including commerce and manufacturing, safety or protection of people, legal compliance with regulations, medical applications, research—just to name a few.

## Measurements for Radiation Therapy

The main drive for the development of radiation measurement standards came about through the recognized need for accurate dosimetry in the applications of radiation to patients. The problem became more acute with the advent of the Coolidge hot-cathode x-ray tube, which by the early 1920's promised to permit therapy up to 200 kV. Therapy at lower energies had been practiced for some time and the clinical attempts at dose control involved a variety of measurement means. For example, barium-platino-cyanide pastiles were used for many years; these change color in accordance with the amount of radiation received. Another technique involved the use of photosensitive film or paper. Both of these techniques involved matching of color or darkening. Another system employed selenium cells which were photosensitive but had peculiar operating characteristics, at best.




*The first NBS standard for measuring x rays was this free air ionization chamber, completed in 1928. An electrical voltage is applied to two parallel metal plates in the chamber (D). X-rays from a tube in the lead cylinder, (A) pass through the chamber (D). x rays from a tube in the lead cylinder are drawn to one plate and their charge is measured by a sensitive electrometer (C).*

Along with these older methods was a wide variety of ionization chambers which, while suitable for control purposes within a given clinic, defied any kind of real comparison because of the lack of a central comparison point, let alone a recognized standard. It is surprising, in looking back over this period extending up until about the middle of the 1920's, to see how relatively close all of these various measurement systems were to each other in spite of the wide variations that existed relative to their fundamental operation.

Attention was directed to all of these problems at the First International Congress of Radiology held in London in 1925, and it is largely for that reason that activity in the area of radiation measurement sprang up quickly all over the world during the following period.

The big push in this country started in 1925 through action of the Radiological Society of North America that organized an x-ray standardization committee. After reviewing the current situation, one of its first recommendations was to urge the start of a major program in the field of x-ray standards and measurements at the National Bureau of Standards.

The next major step took place at the Second International Congress of Radiology in 1928 at which time a definition of the roentgen was adopted. In the meantime, standards programs were well underway in the three major National Standards Laboratories as well as at numerous other points.

With these steps having been taken, and accompanied by the development of reliable portable instruments, mostly using thimble chambers, it was then possible to rely on a central standard system for the uniformity of procedures in radiation therapy. The practical accomplishment of this has depended to a major degree upon the traceability of the measurements from the standards laboratory to the individual clinic, back to the standards laboratory, and then out to other clinics.

As far as clinical dosimetry is concerned, the overall system has been fairly good for many years—better in some areas than others. However, the system has not been good enough because in therapy, more than all

*Lauriston Taylor (left) of the National Bureau of Standards and Walter Binks of the British National Physical Laboratory perform the first intercomparison of x-ray standards between the two countries at the NPL laboratories in Teddington, England, 1931.*

other applications, high accuracy and traceability is essential to the best welfare of the patients involved.

As of today, while the problems remain somewhat the same in principle, they are often technically more difficult and complicated. To begin with we are dealing with higher energy photon—as well as particle-radiation. To be of ultimate clinical value there has to be a capability of comparability between the clinics and between the measurements with various other kinds of radiation.

In addition to the different radiations themselves there are now many different measurement techniques that may be used, such as those involving photoluminescence and thermoluminescence in addition to ionization chambers having special energy responses deliberately built into them.

To be used most effectively in the clinic, all of the radiations and all of the measurement systems will have the same accuracy requirements as the best we have achieved under the simpler systems in the past. This means that their errors must be no greater than 5 percent at the surface of the patient and probably should be better than that. The achievement of this level of accuracy requires a high degree of measurement assurance or traceability.

## Measurements for Radiation Protection

The first tolerance dose for x-ray workers—a dose then considered to be without harm—was proposed by Mutscheller in 1925. It was described as 1/10 of a skin erythema dose to a worker in a year. In turn, the erythema dose was described as the amount of radiation required to produce a defined reddening of the skin when delivered in one treatment. The treatment was described in terms of tube current and voltage, distance, time, and size of irradiated field. This was all based on Mutscheller's observation that a few x-ray workers who had been exposed for several years to radiation calculated to be about 1/100 of an erythema dose over a 1 month period, showed no effects. He then estimated that since it would take some 8 years to accumulate an erythema dose, a tenth of an erythema dose in a year could be tolerated with a comfortable margin of safety.

By 1956, the International Committee on Radiological Protection and the National Council on Radiation Protection and Measurement had lowered the maximum permissible doses for radiation workers to 5.0 rem in a year and 1/10 of that or 500 millirem for the general population. The rem is a unit of radiation dose equivalent based on the biological effects of the radiation. The 1956 maximum is 1/11 the level proposed in 1925 by Mutscheller.

Note two things: (1) no effect on man has ever been observed for exposures at any of the permissible levels used since 1925, and (2) there can be no ascribable accuracy to a permissible dose level.

Today there are discussions leading to reductions of the dose for the population; dose limits in the range of 5-25 millirems in a year are being considered. The question: what would be reasonable requirements for the accuracy of measurements made at these very low doses? Another question: to have some meaning, would not everyone need to be monitored continuously?

Bear in mind that people who live in Bethesda, Md.—altitude 400 feet—receive at least 5 mrem a year more than do people living in downtown Washington. With such large normal variations in environmental radiation,

*continued on page 21*

(Photos by Mark Helfer.)

*Particles to be analyzed with the new micro-Raman spectrometer are "mounted" on the polished surface of a substrate which is chosen to minimize spectral interferences, for example, sapphire or lithium fluoride.*

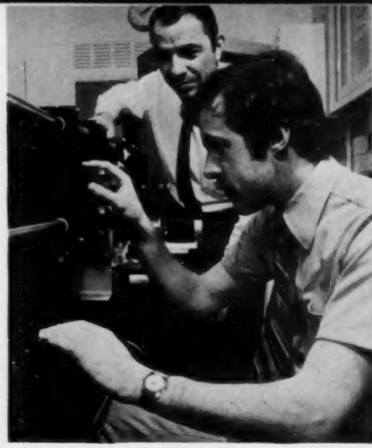
by Madeleine Jacobs
NBS public information specialist

# TRACKING OUR INVISIBLE ENEMIES--NEW INSTRUMENT AIDS ENVIRONMENTAL ANALYSIS

TODAY, public health officials suspect that some of the most potentially hazardous substances in our environment may be "invisible enemies." Resulting from man-made or natural sources, these substances exist as very fine particulates in the air—in most cases too small to be seen with the unaided eye. Breathed into the lungs, however, these particulates may damage the respiratory apparatus.

For this reason, there has been great interest in detecting, measuring, and characterizing particulates, especially those ranging in size from a few hundredths of a micrometer to a few micrometers. (A micrometer is about 40 millionths of an inch). About 2 years ago, NBS scientists developed a light scattering instrument that could be used to determine almost immediately the size distribution and total number of particles in air over the size range 0.05 micrometer to 5 micrometers. Now, NBS scientists have added a new instrument to the arsenal of the analytical chemist that will be especially useful in characterizing individual particulates.

The new instrument, a laser-excited micro-Raman spectrometer, can be used routinely to analyze single particles, one micrometer in size or larger. This is the size of many "primary particulates," of interest to scientists studying air pollution. The one-of-a-kind instrument was developed by Dr. Greg Rosasco with the assistance of Dr. Edgar Etz of the Institute for



*Dr. Greg Rosasco (foreground) and Dr. Edgar Etz have developed a new laser-excited micro-Raman spectrometer capable of routinely analyzing very small particles 1 micrometer in size or larger. By looking through the eyepiece of the spectrometer, Rosasco can position an individual particle of interest for analysis.*

Materials Research, with support from the U.S. Air Force Technical Applications Center. Dr. Wayne Cassatt and Dr. Ilan Chabay of IMR participated in preliminary work. Mechanical fabrication of the instrument was carried out by Carl Barry of the Instrument Shops Division.

### Unique Fingerprint

Rosasco explains that Raman spectroscopy offers a unique "fingerprint" that provides specific information about the structural or molecular formula of major chemical units in a material. For example, the Raman spectrum of a substance containing sulfur and oxygen can be used to determine whether the sulfur and oxygen exist as sulfates, sulfites, or as metal sulfides or oxides. Raman spectroscopy also provides information about the state of aggregation of the chemical units in a material, that is, whether they exist in a crystalline or glass-like phase. Taken with information obtained from other analytical methods, Raman spectroscopy can be used to characterize particulates more completely.

The new instrument is based on the results of an earlier NBS feasibility study as well as on certain features of a design proposed by Block Engineering, Inc., the contractor to the Air Force in an earlier phase of the work. In the feasibility study, the NBS scientists were the first to demonstrate that Raman spectra could be obtained from individual, micrometer-sized particles. In addition, they showed that the spectra obtained on these micro-samples were essentially the same as spectra of these compounds obtained from large bulk samples. This indicated that known Raman data available on large samples would be helpful for purposes of chemical identification of smaller samples.

### Key Features

With this information in hand, the NBS group designed a unique instrument that combined the best available state-of-the-art components along with innovative features. The result is an instrument useful for routine analysis of micro-samples. For analysis, the particles are "mounted" on the polished surface of a substrate which is chosen to minimize spectral interferences; for example, sapphire, lithium fluoride, or highly reflecting metallic substrates can be used. The instrument operation is routine in that any particle of interest in a sample can be simply located, and then rapidly and precisely positioned for measurement.

A key feature of the instrument is that detection of the very weak Raman signal from the particle is optimized and all other sources of interference are minimized. In addition to its precision, the instrument has a high degree of mechanical stability that allows an analyst to conduct measurements on a specific particle for extended periods of time without having to attend to the system. This capability is significant for the detection of signals from optically absorbing particles and for the extension of the measurements to very small, submicrometer particles, of increasing interest to air pollution scientists. The entire instrument is connected to a minicomputer which allows automatic data acquisition for any number of particles of interest to the analyst.

The instrument is so new that the NBS scientists are still exploring its capabilities as an analytical tool. Among the substances being studied are sulfates; for example, sodium sulfate, calcium sulfate, and ammonium sulfate have been measured in the one to three micrometer size range. These compounds were chosen because they are suspected to occur as particulates in the air. Samples such as urban dust and coal fly ash are being analyzed since they also contain particulates important in the environment. The device also is potentially applicable to a number of other areas in which characterization of microscopic samples is important, including analysis of microscopic inclusions in minerals and gems, micrometeorites, dental materials, biological specimens, and microcircuits. □

### RAMAN SPECTROMETER

The new laser-excited micro-Raman spectrometer provides for highly stable and precise positioning of a diffraction limited, focused laser beam and an individual particle specimen at the focal point of an ellipsoidal collection mirror. The scattered light is spectrally analyzed by a commercially manufactured monochromator which incorporates two concave holographic gratings. Photon counting and digital recording techniques are used for measurement of the Raman spectrum. The system is designed for automated, optimized data acquisition under control of a minicomputer.

# TOWARD A NATIONAL ENERGY POLICY

by Mike McCormack

**U.S. Representative Mike McCormack is chairman of the Subcommittee on Energy Research, Development and Demonstration of the House Committee on Science and Technology; chairman of the Subcommittee on Environment and Safety and of the Subcommittee of the Nuclear Breeder Program of the Joint Committee on Atomic Energy; and a member of the Board of Directors of the American Association for the Advancement of Science. He holds a bachelor's and a master's degree in chemistry. The following is excerpted from a speech given by the Congressman at NBS' symposium on Measurement for Safe Use of Radiation, March 2, 1976.**

ONE of the most important realities that the American people must understand is that this nation has, since 1970, truly passed from one major historical era into another. We have passed from an era of cheap, abundant fuels, energy, and materials into an era of shortages and high costs which will, at best, be with us for many decades.

That reality is exceedingly difficult to accept for us who have lived all our lives in a culture built on cheap mobility and the assumption that American affluence was endless. Nevertheless, we must face the fact that we have, almost certainly, already discovered and burned up more than half of all the petroleum and natural gas we have ever discovered, or will discover, on this continent or off its shores, and that it will be gone, insofare as a significant supply of fuel is concerned, by about the end of this century, no matter what price—within reason—we pay for it today.

This will be happening while our demand for energy is doubling, even with a successful and spartan conservation program.

Today, we are consuming about 6 billion barrels a year, about 4 billion barrels of which come from domestic sources. Our domestic production peaked at about 4 billion barrels per year in 1973; we will be down 10 percent in 1977, and will be down to about 1.5 billion barrels a year production by the year 2000.*

Anyone who wants to waste time can do so by quibbling over exact numbers. The message should be as clear as the common sense behind it: we are running out of petroleum and natural gas. This is true for the entire world, including the Middle East. Each nation has its own date with destiny, and few lie very far into the next century.

As our supplies of petroleum and natural gas dwindle, this nation will become dependent for virtually all of its energy on coal and nuclear fission. However, even these sources of energy are, in the long range perspective, only transitional. Although we must increase our reliance upon them from now until sometime in the 21st Century, we must also make plans for phasing them out in the

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* Estimates based on studies by Dr. King Hubbert, Department of the Interior.

more distant future and replacing them with other, still-to-be-developed sources.

In this respect, one general misconception plaguing the Congress as we fund research and development programs for future energy sources is the idea that research and development, lavishly supported, can solve this nation's energy problems in the very near future. Nothing could be further from the truth, as those of you with experience in science and engineering know.

One general misconception plaguing the Congress as we fund research and development programs is that research and development, lavishly supported, can solve this nation's energy problems in the very near future.

Even with a crash program the time required between the successful laboratory demonstration of a concept for the conversion of an energy source to a usable form and the actual significant implementation of this technology varies from 10 to 30 years, and it's usually closer to 30. There is no way, for instance, that a tidal wave of Federal funds could make solar or geothermal energy a significant resource for this nation before the year 1990, or nuclear fusion before the year 2000.

So while we must support an aggressive, imaginative, well-funded program for energy research, development, and demonstration in every area of energy conversion, distribution, storage, consumption, and conservation, we must at the same time recognize that the benefits of a research and development program are long range benefits, and that this nation must proceed for the immediate future with energy sources which are available to us today.

There is much we can do with respect to our existing energy sources. We must undertake aggressive programs of exploration and drilling for oil and gas, onshore and off. We must explore the potential of an oil shale program, and press for early application of improved technologies for secondary and tertiary oil recovery.

We must build new refineries, new ports, new pipelines, and new storage facilities for gas, petroleum, and petroleum products. In spite of the fact that we are running out of petroleum and natural gas, this program, along with the most stringent conservation measures, is our only short range strategy for trying to keep our energy supplies for our existing industrial and societal infrastructure as close as possible to future demands.

Of course, coal is our greatest resource of fossil fuel, and we must rely heavily upon it. However, even a superficial glance should warn us against taking it for granted. We will need to dramatically expand our coal production capacity with new mines that meet modern health and safety standards and have a minimum impact on the environment. We must allow coal to be surface mined, with realistic regulations and responsible reclamation programs.

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It will be necessary to restore our railway system with new roadbeds and new rolling stock, and back them up with slurry pipelines.

These tasks—of mining and transporting coal safely—are of bewildering complexity and dimension.

There is no way that a tidal wave of Federal funds could make solar or geothermal energy significant resources before the year 1990 or nuclear fusion before the year 2,000.

We will, of course, come to depend upon synthetic gaseous and liquid fuels from coal, but the cost of these programs in dollars, manpower, steel, and other critical materials, in water, in logistics, and environmental protection are literally mind boggling. For example, trying to close the gap between supply and demand in natural gas in 1985 would require more coal than is mined today for all other purposes and would cost literally hundreds of billions of dollars.

In spite of all of these problems in mining, cleaning up, transporting, and burning coal, in spite of the costs of converting it to synthetic fuels, we must proceed with an aggressive program for increased dependence on coal. If we are sincere about attempting to solve the energy crisis that faces this nation, we must think in terms of tripling coal production by the end of this century.

As responsible citizens sort out the facts with respect to our energy future, it becomes more and more obvious that one of the greatest strokes of good fortune this nation has experienced is to have our nuclear industry as well advanced as we find it today, ready now to provide much of the energy this nation will need during the next 50 years.

Nuclear energy is the cleanest, cheapest, most reliable source of energy available, with the least environmental impact of any significant option. If we did not have a large block of nuclear energy available to us for the coming decades this country would be in critical danger, even if we succeed in tripling coal production by the year 2000.

Today, there are 58 nuclear power plants licensed to operate in the United States. During 1975, nuclear energy produced 8.3 percent of this nation's electricity, with a higher reliability factor than comparably sized coal plants of the same age. This saved the rate payers of the U.S. more than ½ billion dollars during 1975, as compared to the same electricity produced by fossil fuel by the same utilities. Twelve more plants are scheduled to be on the line within the next 12 months. In addition to these 70 plants, there are 158 more nuclear plants which are under construction or committed. If these plants are all on the line by 1985, and they *can* be if we simply eliminate unnecessary delays and provide for construction capital, then this nation will have a nuclear capacity of about 226 thousand megawatts—about 30 percent of our electric generating capacity—by 1985.

One can appreciate the importance of such progress in view of the fact that each nuclear plant saves the equivalent of from 10 to 12 million barrels of oil a year. Thus, it would require 6 to 7 million barrels of oil a day to produce the same electricity as these 228 plants will generate. This is equivalent to all the petroleum products that the United States imports today, and with our nuclear breeder program—which will be in place by the 1990's—we can convert the uranium we have in our hands—mined and purified—into *five* times all the energy in all the oil possessed by all the OPEC nations combined.

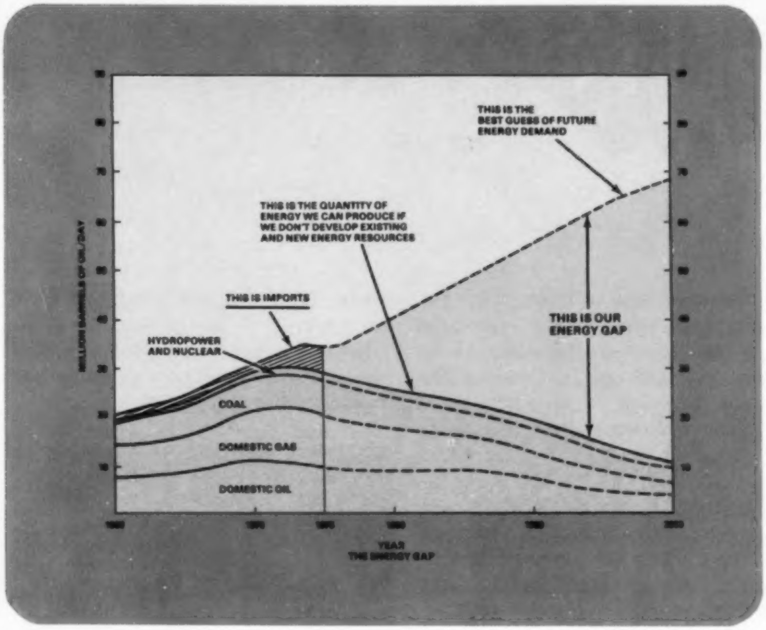
The nuclear industry, just as any other, has some hazardous aspects, and we must assume that at some time in the future there will be some accident causing property damage, injuries, and even deaths. It is crucial however, to ask how likely these accidents are, and how this risk compares to that associated with our other everyday activities.

While it is essential that every conceivable accident be guarded against, as is being done, and every reasonable precaution taken, there is a point of absurdity beyond which the rational public should not be expected to go in imagining nuclear hazards or hypothesizing extreme nuclear accidents.

There is a point of absurdity beyond which the rational public should not be expected to go in imagining nuclear hazards or hypothesizing extreme nuclear accidents.

Recent studies by Dr. Norman Rasmussen of M.I.T. indicate that with 100 plants on the line (as will be the case before 1980) a major accident is 10,000 times less likely to happen in a nuclear power plant than a comparable accident in a non-nuclear facility. Thus, the hazard to any individual or group will be about the same in 1980—with 100 plants on the line—as the hazard of being struck by a meteor.

To put it another way, the chance




that a person will be killed from a nuclear accident in a nuclear power plant in 1980 is one in 5 billion. This means that in 20 years, on the average, one person in the United States would die as the result of a nuclear accident in some one of those 100 plants.

By way of comparison, we kill about 45 thousand Americans a year, and suffer about 2 million serious injuries from automobile accidents. About 12,000 persons burn to death. Overdoses of aspirin and aspirin compounds caused hundreds of deaths per year. About 1,000 persons die from electrical shock. About 160 are killed by lightning. About 3,000 choke to death on food. More than 2,000 are bitten by rabid animals. About 2,000 are killed in airplane accidents.

The fact is that no radiation death or injury has resulted from the operation of any licensed nuclear power plant in the United States; nor has any member of the public been exposed to any radiation in excess of internationally approved standards as the result of the operation of all the 58 nuclear power plants and their supporting activities, and the more than 100 U.S. military nuclear reactors now in service.

Numerous scare stories have been circulated about the radiation impact of a nuclear industry on the general public. Here are some figures that cast some light on this subject.

If we assume 1,000 nuclear power plants on the line in the year 2000, and assuming no advances in emission control technology, the average person in the U.S. will receive the following radiation: 102 millirem per year from natural background, 73 millire per year from medical X-rays and therapeutic radiation, but only 0.4 millirem per year from the operation of all 1,000 nuclear plants and all their supporting activities. That's less than ½ of a millirem, as compared to almost 200 from natural and medical sources.

The complaint has been made that no specific permanent nuclear waste management program has yet been announced by the Energy Research and Development Administration or licensed by the Nuclear Regulatory Commission. Certainly the safe storage of radioactive wastes is a requirement accompanying the beneficial use of nuclear fission. However, this is being approached in the same sound manner which we have used in handling radioactive materials for the last 30 years. Millions of gallons of liquids and thousands of tons of solids containing billions of curies of activity have been handled in an exemplary way, with virtually no harm to anyone and virtually no radiation release to the biosphere. Using techniques that have been developed during recent years, the safe permanent storage of radioactive materials is actually a simple matter of good engineering and good management.

In the near future the ERDA will announce plans for permanent storage of radioactive wastes. The technique almost certain to be chosen involves converting the wastes to a solid glass, similar to Pyrex glassware—and just as inert—and encapsulating these glassified wastes in welded stainless steel canisters. Ten to 12 cannisters, 1 foot in diameter and 10 feet long, holding about 6 cubic feet each, will contain the wastes produced each year by a 1000-megawatt power plant. Each one will represent about $20 million worth of electricity produced. All of this glassified waste from our nuclear energy program through the year 2000 would make a stack 12 feet deep covering a football field. That isn't much volume in terms of the energy produced. The cannisters will be stored in stable geologic formations deep underground.

The cost per kilowatt-hour is very small, and as far as I know, no one has suggested any scenario by which these materials would be introduced into the biosphere.

I am pleased to say that we in the Congress have taken the initiative in establishing well-organized programs in solar energy, geothermal energy, and nuclear fusion.

*continued on page 22*

# HIGHLIGHTS

### Photochemistry Conference

The 12th Informal Conference on Photochemistry will be held at NBS June 28-July 1, 1976. Topics will include: photochemical isotope separation, environmental photochemistry (upper atmosphere and photochemical smog), photochemical and photophysical processes, and photochemical conversion of solar energy. For further information contact: Ronald Johnson, Materials Building B348, NBS, Washington, D.C. 20234.

### New Computer SRM's

Four new Standard Reference Materials are now available for the printed character shape, size, and positioning of constant strokewidth, Style B Optical Character Recognition (OCR-B) characters. These SRM's support the American National Standards Institute and the Federal Information Processing Standards programs for standardization of character styles used in OCR applications. SRM 1901 (price: $558.00) has 118 characters of size I; SRM 1902 (price: $447.00) is a set of 93 characters of size I; SRM's 1903 and 1904 comprise 21 characters each of sizes I and III, respectively (price: $122.00 each). Order from Office of Standard Reference Materials, NBS, Washington, D.C. 20234.

### Oil Spills Target

A recently patented NBS technique can be used to study oil spills in the ocean. An electrolytic stripping cell generates hydrogen gas bubbles which strip organic compounds from sea water. These compounds can be identified and analyzed by gas chromotography. From knowledge of the volume of the sea water and the amount of hydrogen generated, the hydrocarbon concentration in the sea water and the partition coefficient may be calculated. The value of the partition coefficient determines the extent to which hydrocarbons from oil spills will eventually be dissolved.

### Metric Seminars

The NBS Office of Weights and Measures will conduct a series of seminars across the United States to train a core group of weights and measures officials as instructors in the metric system. This will also prepare the officials to respond to inquiries for metric information from consumers, labor, and industry. This is the first step toward meeting the need identified by the National Conference on Weights and Measures for metric education. For more information contact: the Office of Weights and Measures, NBS, Washington, D.C. 20234.

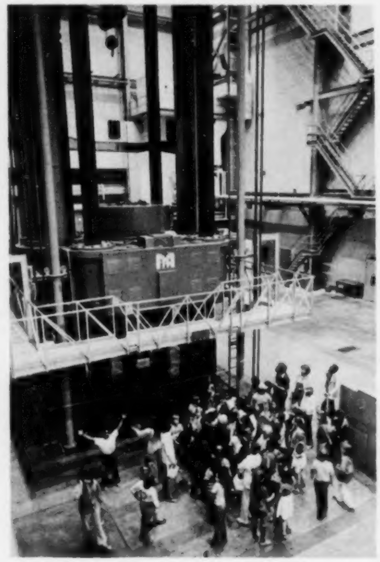
### Atomic Spectra

Data on spectral-line intensities from NBS Monograph 145 are now available on magnetic tape. The tape gives the intensity, character, wavelength, spectrum and energy levels of 39,000 lines in the spectra of 70 elements. Each set of data is presented twice, once ordered by element and once by wavelength. The tape is available from the National Technical Information Service, Springfield, Va. 22161 as NBS Magnetic Tape No. 10 at a price of $250.00.

### NBS Open House

More than 40,000 visitors attended the NBS 75th anniversary open house held May 6-8 at the Gaithersburg, Md. laboratories. Attendees selected from among 85 tour stops on the 233-hectare campus. NBS staff discussed research activities ranging from nuclear studies to consumer product testing.

NBS Boulder, Colo. laboratories will hold an anniversary open house from October 14-16, 1976.



### Thermal Expansion SRM

NBS has issued Tungsten, Standard Reference Materials (SRM) 737, as the first thermal expansion SRM to be certified above 1000 K. The thermal expansion of this sintered tungsten has been accurately determined over the temperature range from 80-1800 K.

This SRM is the fourth in a series of thermal expansion standards. Others available are Borosilicate Class, Fused Silica, and Copper. For further information, contact the Office of Standard Reference Materials, NBS, B311 Chemistry Bldg., Washington, D.C. 20234. Phone (301) 921-2045. □

## NBS Hosts Anniversary Symposium of Standards Laboratory Experts

THE National Bureau of Standards will sponsor a symposium of the National Conference of Standards Laboratories (NCSL), October 6-8, 1976, at its Gaithersburg, Md. campus.

The theme of the symposium, "An Anniversary Review of Our National Industrial Measurement System," marks the 75th Anniversary of the establishment of NBS, the Nation's Bicentennial and NCSL's 15th year.

NCSL represents 200 of the Nation's government, academic and industrial standards laboratories, including members from machine tool, electronics, chemical, optical, lighting, photography, aerospace, transportation equipment, textiles, construction and acoustics industries. It is concerned with the work of measurement technicians, procurement inspectors, instrument makers, quality control technicians, laboratory scientists and government officials.

The major purpose of the symposium is to strengthen channels between laboratories, such as NBS, and American industry. This year the meeting will concentrate on the results of a 3 year NBS study of its role in the National Measurement System. Participants will be asked for comments on the following questions:

- How well does the National Measurement System meet today's industrial needs?
- What is the standards laboratory's role in this system?
- How close are we to metrology laboratory self-evaluation?
- What does metrication mean to the standards laboratory manager?

The National Measurement System is defined as comprising all the elements used to produce measurement data. The NBS study analysed the technical, institutional, conceptual and operational components of the system. It sought to determine the use of measurement data to describe, communicate, decide, and control; in science, industry, technology, and in people's daily lives.

The study has two main parts: A macroeconomic analysis of the cost dimensions of measurement-related activities in the U.S. economy; and 24 microstudies of the major measurement fields in which NBS participates.

Copies of the National Measurement System Study summary reports may be obtained by writing Dr. Raymond C. Sangster, Institute for Basic Standards, NBS, Boulder, Colo., 80302, or by calling him at (303) 499-1000, ext. 4329. ☐

## Information Guides on Ceramics and Corrosion of Metals Published

THE National Bureau of Standards has published the second and third in a series of reference guides for researchers, manufacturers, and users of ceramics and metals.

"Critical Survey of Data Sources: Ceramics," by Dorothea M. Johnson and James F. Lynch of Battelle Columbus Laboratories, an NBS contractor, identifies best data sources in the field of ceramics.

"Critical Survey of Data Sources: Corrosion of Metals," by Ronald B. Diegle and Walter K. Boyd, also of Battelle Columbus Laboratories, identifies best sources of data on the corrosion of metals.

The series of four directories was initiated by the NBS Office of Standard Reference Data. The objective is not simply to list sources of data but to indicate the completeness and degree of evaluation of each source.

The first directory in this NBS series covered the mechanical properties of metals and was published in 1974. The fourth in the series, covering electrical and magnetic properties of metals, will be released soon. Each survey was aided by industry specialists, particularly those involved in the production and use of commercial materials.

The ceramics survey was aided by a task force of specialists organized by the American Ceramic Society, Inc. The directory summarizes both literature (30 handbooks and technical compilations) and information services (7 societies/trade associations and institutes). These services are included in the directory as focal points for information not available in publications.

A $14 billion a year industry, ceramics includes materials and products associated with refractories,

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whitewares, artwares, porcelain enamels, glass, structural clay, cement, and carbon/graphite. A 1975 National Academy of Sciences report cited ceramics as a field of great scientific and technical promise and recommended increased support for ceramic studies.

The ceramics survey should be helpful to those in the ceramic community who are developing new products, those who are interested in quality control, longer life, and lower cost of products, as well as the growing number of ceramic researchers in scientific laboratories.

The Corrosion Data survey was aided by members of the Publications Committee of the National Association of Corrosion Engineers. The survey included an assessment of the scope, assets, and deficiencies of each source. Priority was given to sources containing reliable engineering data.

The corrosion data should aid those who are concerned with reducing the billions of dollars spent annually for corrosion-wasted resources and related losses in industry and government. It should help determine:

- What types of corrosion information are available for a given metal or alloy.
- What alloys are useful in a particular corrosive environment.
- What types of corrosion problems can be expected for a particular alloy-corrodent system.
- Current theories and proposed mechanisms for various forms of corrosive attack.
- In what systems corrosion information is deficient.

Both the ceramics and corrosion data directories cite key handbooks and technical compliations, information centers, technical societies and trade associations. Literature of limited availability is excluded. Both include a materials index, a properties index and a list of useful references not covered in the handbook section.

Copies can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402: "Critical Survey of Data Sources: Ceramics," NBS Special Publication 396-2 (order by SD Catalog No. C13.10:396-2) for $1.25, stock number 0303-01274, and "Critical Survey of Data Sources: Corrosion of Metals," (order by SD Catalog No. C13.10:396-3) for $1.30 □

# Wind Research Aids Designers and Occupants of High-Rise Buildings

A procedure for building designers to use in estimating effects of wind forces on tall buildings has been developed by the National Bureau of Standards. Use of the NBS procedure should contribute to safer building design and increased comfort for occupants of high-rise buildings.

High-rise buildings often sway on days with high-velocity winds. In a few cases occupants have been known to leave the top floors of such buildings during high winds.

The problem is particularly noticeable in buildings constructed after World War II. Before then buildings were constructed with materials, such as brick walls, which provided stiff resistance to high wind pressure. But the use of curtain walls and lighter-weight materials have made modern high-rises more susceptible to swaying.

Swaying is caused to a large extent by the phenomenon called resonance—whereby buildings will vibrate when struck by wind gusts at certain intervals. It is similar to the vibration that may be set off when a column of soldiers marches in step across a bridge.

If a building is properly designed, these resonance effects can be abated. The first step is to evaluate their magnitude in the design stage.

Emil Simiu, of NBS' Institute for Applied Technology, working with Daniel W. Lozier of the Institute for Basic Standards, has presented a procedure for calculating wind response which

*The 11-story NBS Administration Building in Gaithersburg, Md. has been one of the tall buildings studied under the NBS wind research program.*

incorporates recent advances in atmospheric boundary layer flow modeling and random vibration theory. It also utilizes new, efficient numerical techniques developed by NBS' Applied Mathematics Division. The techniques can be used manually or can be incorporated into a computer program.

The procedure for calculating wind response is contained in a new publication, "The Buffeting of Tall Structures by Strong Winds," NBS Building Sciences Series 74. Structural engineers, wind engineering researchers, and building code writers will find the publication extremely useful. It can be ordered prepaid for $1.55 by SD Catalog No. C13.29:2/74 from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Foreign remittances must be in U.S. exchange and include an additional 25 percent of the publication price to cover mailing costs. □

# NBS Publishes Bibliography on Building Collaspe Due to Abnormal Loading

THE sudden collapse of part of a London apartment building following a gas explosion in 1968 has raised concern that some high-rise buildings may be susceptible to a chain reaction type of failure.

This concern has resulted in publication of "Abnormal Loading on Buildings and Progressive Collapse. An Annotated Bibliography," by the National Bureau of Standards.

The 55-page publication contains 377 entries and will be of interest to architects, designers, builders and other members of the construction community.

The bibliography is an annotated listing of articles that have appeared in the technical literature from 1948 through 1973 and articles describing progressive types of collapses which have appeared in the *Engineering News Record* from 1964 through 1973. The references have been selected as most representative of the historical background and state-of-the-art of current building practice.

They cover a broad range of structures, such as apartment buildings and bridges, during and after construction. The entries are arranged chronologically by year and alphabetically within years. Subject and author indexes are included.

A sample entry:

*157. Collapse of 10 Floor Sections Kills Two Workers, Engineering News-Record, March 5, 1970, p. 15.*

*Sections of 10 floors of a 20-story apartment building under construction in Pittsburgh collapsed killing 2 men. Apparently, an overload of masonry block on the concrete plank floor of the 19th floor caused the failure. The weight of the falling block and planking then sheared off 8x12 ft. sections of nine floors of the building, finally dumping an estimated 40 tons of debris onto the 10th floor.*

Authors of the bibliography are E. V. Leyendecker of NBS' Center for Building Technology; N. F. Somes, Office of the Director of NBS' Institute for Applied Technology; J. E. Breen of the Department of Civil Engineering, University of Texas at Austin, and M. Swatta of the Bechtel Corporation, San Francisco. Their work was sponsored by the Office of Policy Development and Research, Department of Housing and Urban Development.

In the London incident, a corner of the 22-story apartment building of precast concrete collapsed after a gas explosion (a loading not normally considered in design) in the kitchen of an 18th floor apartment. The explosion blew out an exterior wall panel. The loss of support provided by the panel resulted in a chain reaction collapse to the roof; the collapse also progressed almost to the ground as debris fell on successive floors below.

This type of chain reaction, or propagation of failure, following damage to a relatively small portion of a structure has been termed "progressive collapse."

An inquiry into the London incident revealed a number of deficiencies in existing codes and standards, particularly as applied to multistory construction. Interim criteria for strengthening existing buildings and designing new ones were adopted.

The new NBS publication, Building Science Series 67, may be ordered prepaid for $1.20 by SD Catalog No. C13.29:2/67 from the Superintendent

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**LOADING** *continued*

of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Foreign remittances must be in U.S. exchange and include an additional 25 percent of the publication price to cover mailing costs. Order microfiche copies prepaid by NBS designation from the National Technical Information Center, Springfield, Va. 22151; the price is $2.25 (domestic) or $2.95 (foreign) a copy. □

# July Date for Frequency Standards Symposium in Colorado

THE Second Symposium on Frequency Standards and Metrology, to be held July 5-7, 1976, at Copper Mountain, Colo., will again provide a discussion forum on most aspects of precision frequency standards and associated metrology. Sponsors of the meeting are the National Bureau of Standards and the International Union of Radio Science.

According to Dr. Helmut Hellwig, symposium chairman, it will follow the "traditions" set by the first such meeting 6 years ago at Foret Morency, Province of Quebec. This means that informality will be emphasized, though there will be scheduled talks on selected subjects.

Symposium topics will relate to frequency standards throughout the electromagnetic spectrum and will include microwave beams, storage devices, stabilized lasers, infrared and optical beams, two-photon techniques, aspects of time and length standards, infrared and visible frequency synthesis, measurement principles and limitations, and the relation of frequency standards to specific scientific disciplines such as relativity.

Hellwig describes the subject matter of the symposium as related to but more specialized than some program areas of the 1976 Conference on Precision Electromagnetic Measurements being held the previous week (June 28-July 1) at the National Bureau of Standards in Boulder, Colo. Time and location proximity of the two meetings was planned to facilitate travel arrangements to both.

The setting of the Frequency Standards Symposium was chosen for its environment of quasi-isolation. There will be much opportunity for discussion and presentation of late ideas and results. To stimulate the exchange of ideas, group eating arrangements have been planned, and there will be evening sessions.

Members of the symposium organizing committee are Claude Audoin, Laboratoire de l'Horloge Atomique, Orsay, France; Gerhard Becker, Physikalisch - Technische Bundesanstalt, Braunschweig, West Germany; Pierre Giacomo, Bureau International des Poids et Mesures, Sevres, France; John L. Hall, National Bureau of Standards, Boulder, Colo., USA; Helmut Hellwig, National Bureau of Standards, Boulder, Colo., USA; David Knight, National Physical Laboratory, Teddington, Middlesex, England; Sigfrido Leschiutta, Istituto Elettrotecnico Nazionale, Torino, Italy; V. S. Letokhov, Academy of Sciences, Akademorodok, USSR; Yoshikazu Saburi, Radio Research Laboratories, Tokyo, Japan, and Jacques Vanier, Laval University, Quebec, Canada; with L. Kenneth Armstrong, National Bureau of Standards, Boulder, Colo., USA, in charge of local arrangements.

Requests for a tentative program of the meeting and inquiries about technical matters may be addressed to Dr. Helmut Hellwig, 277.04, NBS, Boulder, Colo. 80302, USA.

Inquiries about non-technical arrangements should be sent to L. Kenneth Armstrong, Program Information Office, NBS, Boulder, Colo. 80302, USA. □

# NBS Offers Users Guide for The New Synchrotron

THE National Bureau of Standards has issued a User Guide to its new Synchrotron Ultraviolet Radiation Facility (SURF II).

"A User Guide to SURF at the National Bureau of Standards," by D. L. Ederer and Stephen C. Ebner, describes the properties and characteristics of synchrotron radiation as well as the instrumentation available at the facility.

The facility is unique in that it is especially adapted to radiometric calibrations. The idea for the machine, an electron storage ring, was conceived at NBS by Drs. Robert P. Madden and David L. Ederer to upgrade the original NBS synchrotron. SURF II provides higher intensity, double the wavelength range, and increased temporal and spatial stability, thereby enhancing NBS measurement capability.

The primary purpose of SURF II at NBS is to apply synchrotron radiation to help solve the Nation's measurement problems. However, SURF II will also be available for other uses and to other members of the scientific community besides the NBS staff.

Extreme ultraviolet radiation such as produced by SURF is an important tool for analyzing plasmas (electrically conducting gases) connected with controlled nuclear fusion programs. It has possible application for the fabrication of miniaturized electronic circuits and in perfecting extreme ultraviolet lasers and laser-related technology.

Copies of the User Guide or other information about SURF II may be obtained by writing to Dr. Madden, Chief, Far Ultraviolet Physics Section, Room A251, Physics Bldg., Washington, D.C. 20234. □

**RADIATION** *continued*

is it necessary that measurements of the dose to the population be measured with an accuracy of say ±10 percent? Or perhaps ±200 percent? Let us not completely lose our sense of humor.

### Measurements for Regulatory Purposes

Measurements and measurement accuracy for regulatory purposes seem to fall outside of the normal scheme of laboratory practices. Actually, it would seem that regulatory practices should be for one or both of two situations: (1) a strict control over the design intentions for a facility that may have the potential for causing injury to persons, and (2) a control program to assure that injuries are not being caused to persons.

The first is a rational approach to the problem provided it is carried out reasonably. Unfortunately (1) and (2) are rarely separated in spite of the fact that in the field of ionizing radiation the control levels that have been used for the past 40 years have been so low that no deleterious effects have ever been found for persons exposed within those limits.

I sometimes think that the real regulatory purposes may, consciously or unconsciously, be to assure compliance for compliance sake; surely not just to protect people.

Let us consider what may be reasonable and rational requirements for accuracy and traceability. The following may be suitable for discussion purposes but I do not pretend to necessarily recommend them; they are based mainly on the significance of the exposures involved:

(1) For occupational exposures near the upper limit of 5 rem in a year—±10 to 20 percent.

(2) For occupational exposures of less than ½ the upper limit—±25 to 50 percent.

(3) For non-occupational exposures of less than 25 mrem in a year—factor of 10.

(4) For non-occupational exposures of the order of 100 mrem in a year—factor of 3.

(5) For non-occupational exposures of the order of 500 mrem in a year—±50 percent.

My message:

1) Assure the existence of basic standards of the necessary accuracy.

2) Assure the existence of transfer standards of the necessary accuracy.

3) Develop adequate and reliable field instruments.

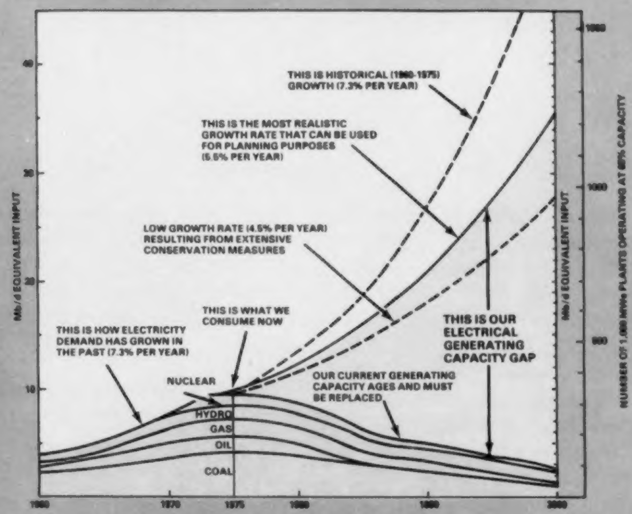
4) Develop adequate means for calibrating field instruments.

5) Assure that at all times any instrument reading anywhere can be traced to its basic calibration source.

6) In measurements anywhere, don't lose your sense of humor. □

*The SURF II facility is unique in that it is especially adapted to radiometric calibrations.*

**ENERGY** *continued*




THE ELECTRICAL GENERATING CAPACITY GAP

The Solar Heating and Cooling Demonstration Act of 1974 provides a 5-year program to demonstrate the commercial feasibility of using solar energy to heat and air condition residences and other buildings. We envision having 2,000 demonstration solar heating units on the line within 2 years, and, in addition, 2,000 combined heating and cooling demonstration units in 4 years.

We have also established a long range, comprehensive program for all aspects of solar energy conversion to electricity, including wind conversion, thermal electric conversion, photovoltaics, ocean thermal gradients, bioconversion, and the incineration of wastes for energy or their conversion to useful fuels.

Solar energy will clearly play an important role in our future, and I am proud of the overall program we have established. We have increased funding for solar energy research and development about one hundred times during the 5 years I have been involved in the program.

However, we must keep the potential for solar energy in perspective. With well-managed, well-funded, aggressive programs, we may, if we are lucky, be able to provide 1 percent of our energy from solar heating and cooling, and another 1 percent from all other methods of solar energy conversion by the year 1990, but almost certainly not before. For instance, if we were to convert 10 percent of our 70 million homes in this country to solar energy for heating and cooling by 1990—and that would be a truly prodigious undertaking—the energy saved would be only slightly more than 1 percent of our national energy demand.

The same general perspective applies to geothermal energy. In the Geothermal Research, Development, and Demonstration Act of 1974, our goal is to have from 6 to 10 geothermal demonstration plants on the line by 1980. These are small plants, generating up to 50 megawatts of electricity each, using presently undeveloped types of geothermal energy such as hot dry rock formation, hot water deposits, and geopressured water. Here again, prudence must govern our optimism. Even with such a crash program, it is unlikely that we can produce 1 percent of our total energy from geothermal sources before 1990.

Nuclear fusion presents a similiar picture, but with much more promising potential. We have experienced very encouraging progress in controlled thermonuclear research, and certainly we are now operating on a new plateau—one which we have dreamed of and sought for 20 years. Now, for the first time, we understand the physics and the dynamics of the plasma in which the thermonuclear reaction must take place. Now, for the first time, we are in a position to move forward with a much more aggressive research program; and now we can, with considerable confidence, predict success.

I believe that we can have our first commercially feasible fusion electric demonstration plant on the line by the mid or late 1990's, but not before, and this will require massive support, starting now, for materials research and development and for engineering studies. If this program is successful, we may—in the 21st Century—be able to look forward to providing unlimited quantities of clean, cheap energy forever, not only for this country but for all mankind. We may also look forward to phasing out the burning of fossil fuels and the use of nuclear fission to produce electricity—in the 21st Century.

It should be completely obvious that we cannot reach these goals of the 21st Century unless we establish intelligent and responsible policies and programs during the balance of

the 20th Century. It should be obvious that this is no time for pretending that there are simplistic solutions to the tangle of interlocking and complex problems that face us. It should be obvious that we cannot afford to base our policies on fantasies, fears, hopes, or prejudices. It should be just as obvious, however, that this nation can develop policies and programs which will provide for adequate energy to maintain our economic stability and standard of living, while protecting or even improving our environment and the health and physical well-being of our citizens.

I believe we can do it if we establish energy policies that do make sense and if we implement them at every level right away. We have faced tough problems before. Many of us here lived through the Depression and helped fight the 2nd World War. We never doubted for a single moment what our purpose was or that we would ultimately overcome the difficulties that beset us during those trying times. I am convinced that if the American people exercise the same resilience, confidence, and good sense that we have demonstrated in the past, and if we demand responsible leadership from all of our public officials, appointed or elected, and if we demand policies based on scientific facts, we can overcome the problems that face us today, and help build a better world. □

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# PUBLICATIONS

## of the National Bureau of Standards

### Building Technology

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